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Turhan ÇETİN, Ergin HAMZAOĞLU, Yurdal DİKMENLİ, Bahadır KILCAN

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New Horizons in Eduational Sciences

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Foreword

Technology has influenced all the aspects of our lives by causing inevitable changes and improvements in every field. Naturally, the world of science has greatly benefited from this change and development. In consequence, the rapid circulation of information and technology in the scientific world has increased the cooperation among scientists. This cooperation highly contributes to researches and studies in the fields of language, history, literature, education, economy, social and cultural life, politics, sports, tourism, and media and communication along with many other areas.

Thus, this book contains **New Horizons in Educational Sciences** in parallel with the improvements in the world of science. In this context, educational sciences, classroom education, geography education, science education, environmental education, psychological guidance and counselling teacher preparation, teaching methods and approaches. It took about one year to prepare and print the book. We would like to express our deepest gratitude to our friends who contributed to this process. We also thank SRA academic publishing staff.

Finally, very special thanks go to the authors who contributed to our book with their researches. It is our greatest wish that this book will increase the cooperation among scientists to make the world a better place.

Kind Regards.

Editors

Turhan ÇETİN, Ergin HAMZAOĞLU,

Yurdal DİKMENLİ & Bahadır KILCAN

08. 10. 2019

CHAPTER 9

The Evaluation of Ecological Footprint Awareness Levels of Science and Technology Teacher Candidates by Artificial Neural Networks

Semra BENZER[1], Recep BENZER[2] & İçten BİRGÜL[3]

1. Introduction

Mankind has always benefited from natural resources to meet its needs from past to present. The world natural resources are also decreasing with population growth. How many planets like the world are needed in the future if individuals continue to live within the framework of their current consumption habits? Determining the answer to this question is important for a livable world to be left to future generations. In this regard, "ecological footprint" is one of the methods used. Ecological Footprint along with indication of sustainable lifestyle is a computing method that gives an opportunity to compare the needs of people on the earth with renewable capacity of the world (Eren et al., 2016). It is possible to calculate the ecological footprint by dissolving a test for the individual past and present. This test examines subheadings such as feeding habits, transportation routes and energy savings.

A disproportionate increase in world population brings with its skewed urbanization and industrialization. This causes various environmental problems such as destruction of natural areas, environmental pollution, seasonal changes, global warming, ozone depletion. In addition, people's unconscious and unpredictable approach to the issue triggers environmental problems.

The sustainable environment represents a process. It aims to protect the environmental values of future generations in social, economic, cultural and physical fields. One of the concepts that comes together with the concept of sustainable development is the ecological footprint (Du et al., 2006). For this purpose, it is the process of developing works without jeopardizing the existence and quality of the resources that will be needed in the future and today.

The first study on ecological footprint was conducted with the study named “Ecological footprints and appropriated carrying capacity: what urban economics leaves out” (Rees, 1992). In section 21 of the 21st agenda of UNESCO studies, it was noted that the development of phenomena such as education, environmental awareness, value judgments, attitudes and behaviors is directly proportional to sustainable development (UNESCO, 2002).

Dinc (2015) has emphasized the importance of global ecological footprint in Turkey. Many ecological footprint studies have been conducted on the awareness, attitudes and behaviors of elementary school students, prospective teachers and engineering students towards sustainable life (Van den Bergh and Verbruggen, 1999;Keleş et al., 2008; Erdoğan and Tuncer, 2009; Keleş, 2011;

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Coşkun, 2013; Yıldız and Selvi, 2015; Eren et al., 2016, Eren et al., 2017; Özgen and Aksoy, 2017; Destek and Sarkodie, 2019).

Science and technology teacher candidates are responsible for carrying social awareness and creating and supporting this awareness in their environment. In the future, it is aimed that science teachers will be able to instill this awareness to the students and raise a conscious society.

ANNs are mathematical models inspired by biological neural networks contained in human brain. Having similar characteristics to those of biological neural networks, these systems attempt to learn tasks and determine how they will react to new tasks by means of creating their own experiences through the data obtained by using the predetermined samples (Sagiroglu et al., 2003). The implementation of a user-friendly software tool based on neural network classifiers was described for predicting the student's performance in the course of Mathematics of the first year of Lyceum (Livieris et al., 2012). Neural networks were also used to predict MBA (Master of Business Administration) student success (Naik and Ragothaman, 2004). The authors classified applicants to MBA program into successful and marginal student pools based on undergraduate GPA (Grade Point Average), undergraduate major, age, GMAT (Graduate Management Admission Test) score using a neural network with three layers. There is some educational research (Naik and Ragothaman, 2004; Lykourentzou et al., 2009; Paliwal et al., 2009; Livieris et al., 2012; Oancea et al., 2013; Kardan et al., 2013; Khan and Kulkarni, 2013; Naser et al., 2015; Yorek and Ugulu, 2015; Bahadır, 2016; Özdemir and Polat, 2017; Matzavela et al., 2017) related to artificial neural networks. The great advantage of neural networks is that they can be used to make predictions in several aspects in education. Using neural networks and analyzing parameters such as student satisfaction, can lead to high prediction accuracy (Kardan et al, 2013).

Questionnaires also became useful tools for studies with low budget, helping them plan correctly the next semesters without excessive spending. It was very valuable to predict the next prefer that each student would choose, and it could be achieved by using questionnaires. In that direction the contribution of Artificial Neural Networks (ANNs) was remarkable (Matzavela et al., 2017). ANNs are directed graphs with weights and they are used, apart from education, in weather forecasting, predicting earthquakes, calculating the financial risk of a loan, in automatic pilots, in stock exchange.

The aim of this study is to determine whether there is a difference between the science and technology teacher candidate’s ecological footprint awareness levels with ANNs which is used as an effective prediction method in various sectors and as an alternative for traditional methods in the field of education.

2. Methods

In the study, the data will be collected with the “Ecological Footprint Awareness Scale” developed by the authors of the thesis “Investigation of ecological foot print levels of classroom teacher candidates” (Çoşkun and Sarıkaya, 2014). Survey model is based on the quantitative stage and it is convenient to general survey model. The qualitative research is based on the views of the participants or the interests, skills, abilities, attitudes, etc. of a topic or event which are usually based on larger samples than on other studies (Büyüköztürk et al., 2011).

In order to find answers to the sub-problems of the study, six questions containing demographic characteristics were written to the first part of the questionnaire. In the second part of the questionnaire, 83 items, which are thought to be aimed at detecting Ecological Footprint Awareness, were written according to the information obtained from the studies of different researchers. The study was applied to 120 students consisting of Gazi University Gazi Education Faculty of science

and technology teacher candidates's 1st , 2nd, 3rd and 4th classroom students in 2015-2016 academic year. A total of 120 students were studied at 30 student each grade level.

In the analysis of the data; arithmetic mean, standard deviation, independent groups t test, correlation and one-way analysis of variance (ANOVA) statistical techniques will be used. The analysis of the data will be done with SPSS 19.0 package program and the significance level will be taken as 0.05 in t test and variance analysis.

The highest score on the "Ecological Footprint Awareness Scale" will be 5 and the lowest score will be 1. Independent groups t test will be used to find out whether science teacher candidates' ecological footprint awareness varies according to gender and grade level. One-way analysis of variance will be used to find out if there is a significant relationship between the groups according to their level of residence, economic income, education level of parents and ecological footprint awareness of science teacher candidates.

In this study, it is to be able to make an effective prediction regarding the attitudes of science and technology teacher candidates in Gazi University towards the ecological footprint awareness according to some variables with ANNs which is used as an effective prediction method in various sectors and as an alternative to traditional methods in the field of education.

Qualitative data obtained from student answers to open-ended questions were used to train and test the ANNs model. 70% of this data was used for training of the network and the remaining 30% was used for testing the network (Hagan et al., 1996). Likert-scale survey is usually in a non-numeric form. For neural network training, responses were converted to the range of 0 to 1. The mapping shown in Table 1 was used. It was used for the traditional education approach by 1-5 numerical values for the Likert-scale.

Table 1. Likert-scala value

Value	Normalized for ANNs	Traditional Value
1	0.24	1
2	0.42	2
3	0.58	3
4	0.74	4
5	0.90	5

The body of an artificial neuron then sums the weighted inputs, bias and "processes" the sum with a transfer function. In the end, an artificial neuron passes the processed information via output(s). the benefit of artificial neuron model (Krenker et al., 2011) simplicity can be seen in its mathematical description below:

$$y(k) = F\,.\,(\sum_{i=0}^{m} w_i(k).\ x_i(k))$$

Where:

$w_i(k)$ is weight value in discrete time k where i goes from 0 to m,

$x_i(k)$ is input value in discrete time k where i goes from 0 to m,

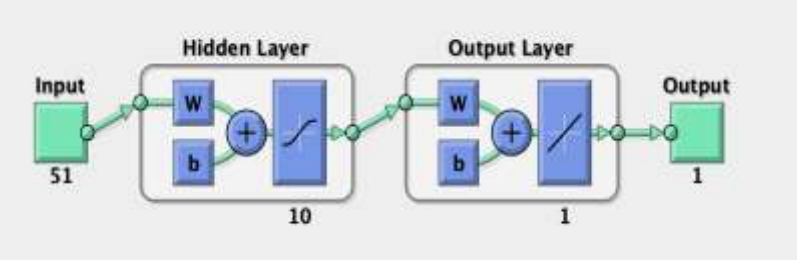
F is a transfer function,

$y_i(k)$ is output value in discrete time k.

Neural network consists of three layers (Figure 1). The first layer has k input neurons which send data via connection links to the second layer of M hidden neurons, and then via more connection

links to the third layer of output neurons. The number of neurons in the input layer is usually based on the number of features in a data set. The second layer is also called the hidden layer.

Figure 1. Artificial Neural Networks model diagram



The supervised learning method trained with the network structure (Back-propagation Networks) will be used to solve the problems in this study. The transfer function, (V_N is normalized data, V_N is data to be normalized, V_{min} is the minimum value of the data, V_{max} is the maximum value of the data) mostly used as a sigmoid or a logistic function, gives values in the range of [0,1] and can be described as (normalization):

$$V_N = 0.8\, x \left(\frac{V_R - V_{min}}{V_{max} - V_{min}}\right) + 0.1$$

MATLAB is a multi-paradigm numerical calculation software and fourth generation programming language. Neural Network Toolbox of MATLAB was used for the ANNs calculations. The coefficient correlation (R^2) was calculated by MATLAB.

The correlation between two variables numerically describes whether larger and smaller average values of one variable are related to larger or smaller than average values of the other variable. It measures the strength and direction of a linear relationship between two variables and can be described as:

$$r = (R^2) = cor(x,y) = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{(x_i - \bar{x})^2 (y_i - \bar{y})^2}}$$

It has been determined the correlation coefficient into "weak," "moderate," or "strong" relationship. While researchers would agree that a coefficient of <0.1 indicates a negligible and >0.9 a very strong relationship. For example, a correlation coefficient of 0.65 could either be interpreted as a "good" or "moderate" correlation, depending on the applied rule of thumb.

3. Results

The distribution of the participants in 5 subgroups (Food, Energy, Transportation and Housing, Waste and Water Consumption) according to gender is shown in Table 2. It is seen that the number of women participating in the research is twice the number of men participating in the research. The distribution of the participants according to their grade levels is shown in Table 3.

Table 2. Distribution by gender

	N	%
Women	80	66.7
Men	40	33.3
Total	120	100

Table 3. Distribution by grade levels

	N	%
1st Grade	31	25.8
2nd Grade	28	23.2
3rd Grade	30	25
4th Grade	31	25.8
Total	120	100

ANOVA (One-Way ANOVA) was conducted to determine whether science teacher candidates' awareness of ecological footprint differed according to grade level and the results are shown in Table 4.

Table 4. Differences of science teacher candidates' awareness about ecological footprint according to class level

Subgroups	Grade Level	N	X	Standard deviation (S)	F	P
Food	1	31	3.23	0.53	4.18	0.01**
	2	28	3.38	0.34		
	3	30	3.19	0.59		
	4	31	3.02	0.58		
Energy	1	31	2.98	0.62	3.00	0.03*
	2	28	3.45	0.54		
	3	30	3.32	0.64		
	4	31	3.31	0.68		
Transportation and Housing	1	31	3.92	0.74	5.95	0.00**
	2	28	4.47	0.35		
	3	30	4.33	0.51		
	4	31	4.16	0.60		
Waste	1	31	3.59	0.71	1.28	0.28
	2	28	3.92	0.47		
	3	30	3.68	0.74		
	4	31	3.62	0.66		
Water Consumption	1	31	3.74	0.68	3.73	0.01*
	2	28	4.32	0.60		
	3	30	4.09	0.67		
	4	31	4.01	0.64		

*p<0,05; **p<0,01

Mean scores for the dimensions subgroups of the scales change between 2.98 and 4.47. The highest score was found for transportation and housing (4.47) in 2nd class and the lowest score was found for energy (2.98) in 1st class.

Results of the current study showed that science and technology teacher candidates have relatively high level of awareness on the ecological footprint. Their awareness level on the transportation and housing and water consumption dimensions found to be higher than the other dimensions. This result consisted with previous research reporting that the highest level of the awareness found on the dimensions of water consumption and lowest level of the awareness found on the food dimension of the ecological footprint (Coşkun and Sarıkaya, 2014; Keleş, 2007; Keleş et al., 2008, Şahin et al., 2018).

In terms of one-way analysis of variance, there was a significant difference between class level and food sub-dimension (F: 4.18, p <0.05). Accordingly, the ecological footprint awareness averages of 4th grade students were significantly lower than the 2nd and 3rd grade students' ecological footprint averages. It can be thought that this result stems from the inability of 4th grade students to control

their consumption habits due to their process. Ecological footprint awareness of prospective science teachers shows similar results with the literature of grade level.

The capabilities of ANNs can allow us to implement them in complicated problems and eliminate that disadvantage, minimizing time and cost. Artificial Neural Networks (ANNs) evaluations of the obtained data were made with MATLAB (R2015b). This study is implemented using Neural Network Toolbox (neural fitting) in MATLAB for the ANNs calculations. Data of questionnaire was divided into xpthree parts: training, validation and test sets. Functions built in MATLAB were used for these sets.

The prediction models established with Artificial Neural Networks are generally chosen as 70% training, 30% validation and testing. However, it has been reported in the literature that better results can be obtained with different data groups (Zhang et al., 1998). In this study, 64 ANNs models were designed, and the results were compared. ANNs model was established as 60%, 65%, 70%, 75%, 80%, 85% and 90% training data and 5%, 10%, 15%, 20% and 25% validation and testing data. Similarly, the number of neurons in the hidden layer of ANNs models was established as 5, 10, 15 and 20. ANNs model's results and the best four ANNs results is shown in Table 5.

Table 5. The results of ANNs model and the best ANNs models

Percent of Data				MSE			R			ANNs Model		Best
Training	Validation	Test	Neuron (N)	Training	Validation	Test	Training	Validation	Test	MSE	R	
90	5	5	5	2.08225e-5	1.61194e-5	8.08949e-5	0.998885	0.755256	0.574272	2.35681e-5	0.998617	
90	5	5	10	2.23803e-5	7.12469e-5	5.36686e-5	0.998871	0.619812	0.276476	2.63549e-5	0.998418	
90	5	5	15	4.81379e-5	3.16244e-5	5.53403e-5	0.997270	0.621084	0.741546	0.86487e-5	0.999457	1
90	5	5	20	2.60400e-2	2.95382e-5	1.26328e-6	0.999985	0.592052	0.277167	0.79634e-5	0.999500	
85	5	10	5	2.80316e-5	1.58526e-1	6.22496e-5	0.470731	0.618146	0.952105	7.89084e-3	0.210995	
85	5	10	10	9.03832e-6	4.54547e-5	4.82041e-5	0.999514	0.0040497	0.270173	1.47283e-5	0.999079	
85	5	10	15	5.84287e-6	7.30384e-5	4.13507e-5	0.999686	0.0240612	0.373815	1.26963e-5	0.999209	
85	5	10	20	8.59967e-6	1.93150e-5	1.16045e-4	0.999737	0.7411950	0.299123	1.97867e-5	0.998906	
85	10	5	5	1.45743e-5	2.65902e-5	4.23859e-5	0.999193	0.167421	0.424498	1.65493e-5	0.998974	
85	10	5	10	1.99108e-5	2.02171e-5	5.40269e-5	0.998877	0.492603	0.601770	2.16177e-5	0.998668	
85	10	5	15	1.11943e-5	5.79465e-5	7.33283e-5	0.999487	0.128520	0.269662	1.65936e-5	0.999146	
85	10	5	20	1.68943e-5	5.93157e-5	2.52084e-5	0.999389	0.157271	0.728382	1.94102e-5	0.999123	
80	5	15	5	3.78104e-5	2.83835e-5	6.55738e-5	0.998230	0.242392	0.123630	4.14731e-5	0.997557	
80	5	15	10	1.60911e-5	4.44865e-5	4.89128e-5	0.999262	0.724700	0.603363	2.23817e-5	0.998740	
80	5	15	15	4.42218e-5	2.49284e-5	1.74222e-6	0.999313	0.701492	0.292323	6.26046e-5	0.997412	
80	5	15	20	5.37430e-4	1.58166e-5	1.55494e-5	0.999727	0.761553	0.289805	2.82241e-5	0.998267	
80	10	10	5	3.81724e-5	1.52151e-1	4.52252e-5	0.549364	0.998292	0.487489	1.51244e-2	0.987921	
80	10	10	10	2.77952e-7	1.29717e-4	1.80453e-4	0.996543	0.999390	0.171161	3.09836e-5	0.998229	
80	10	10	15	1.32721e-6	6.83401e-5	2.06755e-4	0.999932	0.292887	0.388171	2.83461e-5	0.998220	
80	10	10	20	1.04451e-5	3.93818e-5	8.27807e-5	0.999470	0.442262	0.463996	2.04886e-5	0.998709	
80	15	5	5	3.26309e-5	4.08254e-5	3.76268e-5	0.998490	0.451744	0.351936	3.40976e-5	0.998005	
80	15	5	10	8.73894e-5	4.06779e-5	1.07153e-4	0.997488	0.574180	0.266384	8.14207e-5	0.997038	
80	15	5	15	1.65330e-5	6.62878e-5	1.48199e-4	0.999357	0.152968	0.413074	3.04635e-5	0.998236	
80	15	5	20	9.32018e-6	4.05769e-5	4.37083e-5	0.999598	0.295279	0.696835	1.56751e-5	0.999061	
75	5	20	5	2.86250e-5	7.36285e-5	1.61279e-5	0.000262	0.725531	0.188055	5.71682e-5	0.997781	
75	5	20	10	9.04200e-4	3.16262e-5	2.10000e-2	0.862533	0.724800	0.999163	4.18900e-3	0.998404	4
75	5	20	15	1.14322e-7	1.77127e-4	1.67449e-4	0.999994	0.431610	0.143645	4.20822e-5	0.997355	
75	5	20	20	1.12442e-7	2.91488e-4	2.61080e-3	0.998433	0.641282	0.998718	5.32384e-4	0.998186	3
75	15	10	5	9.98654e-6	6.45527e-5	7.25443e-5	0.999557	0.390128	0.421043	2.43079e-5	0.998570	
75	15	10	10	4.109994e-5	4.36141e-5	7.22120e-5	0.998622	0.418106	0.668610	4.45590e-5	0.997937	
75	15	10	15	1.56687e-5	7.37180e-5	4.31229e-5	0.999261	0.136157	0.190935	2.70268e-5	0.998306	
75	15	10	20	3.27941e-5	5.71587e-5	1.99713e-4	0.999860	0.542374	0.165222	5.29726e-5	0.998320	

Percent of Data				MSE			R			ANNs Model		Best
Training	Validation	Test	Neuron (N)	Training	Validation	Test	Training	Validation	Test	MSE	R	
75	20	5	5	3.32673e-5	4.20788e-5	4.41359e-5	0.998430	0.471268	0.819998	3.55540e-5	0.997777	
75	20	5	10	1.33138e-4	4.83443e-3	1.72622e-4	0.117900	0.997071	0.243334	1.06758e-3	0.983748	
75	20	5	15	1.18879e-5	6.56094e-5	9.36885e-5	0.999440	0.217496	0.807503	2.65996e-5	0.998323	
75	20	5	20	1.35407e-4	1.38238e-4	2.20265e-4	0.997458	0.877235	0.911502	1.40177e-4	0.995213	2
70	5	25	5	4.48526e-5	1.48639e-4	5.36371e-5	0.990055	0.473906	6.51221	5.21771e-5	0.996733	
70	5	25	10	2.59346e-5	8.68542e-5	5.91526e-5	0.999546	0.891965	0.324146	3.71913e-5	0.998655	
70	5	25	15	1.39755e-5	5.94350e-5	7.71925e-5	0.999408	0.601853	0.803453	3.19033e-5	0.997989	
70	5	25	20	6.00993e-6	8.19315e-6	1.10248e-4	0.921515	0.764418	0.998923	3.19624e-5	0.998663	
70	10	20	5	1.77609e-5	2.50312e-5	5.70555e-5	0.999450	0.552805	0.398659	2.62759e-5	0.998586	
70	10	20	10	6.14254e-5	1.00369e-4	1.77856e-2	0.683869	0.173755	0.985062	3.58083e-3	0.957937	
70	10	20	15	1.67895e-5	3.70372e-5	5.87523e-2	0.785216	0.335599	0.994512	1.16688e-2	0.954923	
70	10	20	20	7.72430e-6	6.25435e-5	7.84751e-5	0.999775	0.359209	0.517830	2.71941e-5	0.998348	
70	15	15	5	1.06762e-5	2.29592e-5	3.28069e-5	0.999545	0.628907	0.520019	1.57956e-5	0.999020	
70	15	15	10	6.66567e-5	1.90986e-4	7.40432e-5	0.999574	0.565093	0.309606	8.62509e-5	0.998032	
70	15	15	15	2.21333e-5	4.54886e-5	6.76536e-5	0.999334	0.352757	0.135580	3.23793e-5	0.998404	
70	20	10	20	1.20404e-4	1.64961e-4	9.33124e-3	1	0.371585	0.999551	1.41265e-3	0.998568	
70	20	10	5	9.86125e-5	5.51705e-3	2.18404e-4	0.484941	0.999443	0.484643	1.18522e-3	0.997519	
70	20	10	10	3.27161e-6	7.90331e-5	8.72872e-5	0.999860	0.838172	0.245424	2.66308e-5	0.998323	
70	20	10	15	6.73244e-6	7.39100e-5	9.41512e-5	0.999782	0.28280	0.106834	2.87265e-5	0.998298	
70	20	10	20	4.79713e-6	6.76001e-5	1.26856e-4	0.999790	0.113259	0.133621	2.93589e-5	0.998158	
70	25	5	5	3.22463e-5	1.25866e-2	3.41537e-5	0.441274	0.999065	0.190108	3.14500e-3	0.996803	
70	25	5	10	1.49315e-5	3.53038e-5	4.39081e-5	0.999359	0.399810	0.521862	2.14194e-5	0.998676	
70	25	5	15	1.074464e-4	1.51799e-4	2.20404e-4	0.999116	0.105721	0.228528	1.24057e-4	0.996770	
70	25	5	20	4.24441e-6	1.15931e-4	6.94645e-5	0.999911	0.295328	0.120370	3.51695e-5	0.997913	
65	15	20	5	1.76340e-5	6.83071e-5	4.42862e-5	0.999270	0.163880	0.333684	3.04585e-5	0.998092	
65	15	20	10	5.74485e-6	6.11359e-5	2.35676e-2	0.920609	0.463308	0.999282	4.68742e-3	0.998493	
65	15	20	15	2.92079e-6	1.11465e-4	1.13690e-4	0.99989	0.406625	0.750498	4.10386e-5	0.997816	
65	15	20	20	2.06178e-6	8.66506e-2	9.43839e-5	1	0.976306	0.158880	1.29089e-2	0.931243	
65	20	15	5	2.17036e-5	3.62659e-5	4.54913e-5	0.999165	0.409683	0.464077	2.81307e-5	0.998397	
65	20	15	10	1.57341e-5	4.26875e-5	4.60755e-5	0.999532	0.520768	0.315232	0.25593e-5	0.998531	
65	20	15	15	4.39344e-6	7.91821e-5	2.16136e-4	0.999905	0.340169	0.268173	5.07265e-5	0.996817	
65	20	15	20	8.26125e-9	4.21166e-3	5.66017e-4	0.999990	0.997810	0.364665	9.19578e-4	0.994455	

The distribution of the data over the best obtained ANNs model is shown in Figure 2. Performance and graphical presentation of the overlapping between the actual and predicted values for the results of the regression on learning, validation and test clusters in MATLAB for questionnaire data are shown in Figure 3.

Figure 2. The distribution of the questionnaire data

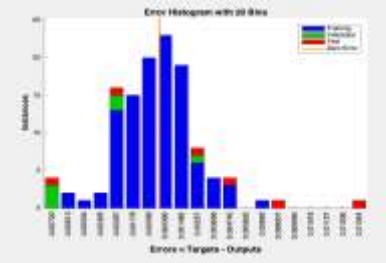
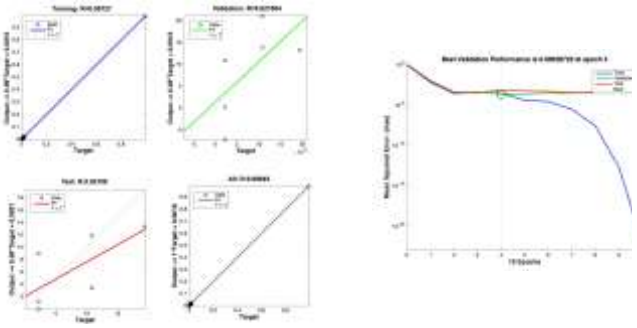


Figure 3. The actual and predicted values for the results of the regression and performance



In this study, the results of the ANNs model obtained with the ecological footprint awareness weight average are given in Table 6. In this study; it is seen that the lowest average is 1.13 and the highest average is 3.73 when the answers obtained from the questionnaire are evaluated.

Table 6. ANNs results

ANNs	Number of sample	MSE	R
Training	108	4.81379e-5	0.997270
Validation	6	3.16244e-5	0.621084
Test	6	5.53403e-5	0.741546
All data	120	0.86487e-5	0.999457

According to ANNs results; The average weight of ecological footprint awareness was 2.35. Considering that the ecological footprint awareness weights obtained in this study are between 2.50 and 5.0, it is seen that the ecological footprint awareness is weak.

4. Conclusion

The most important step in trying to compensate for this is that the human being who is confronted with the problems that arise as a result of the deteriorations in the ecological balance is aware of his actions. Knowing the nature of human activities, how much harm it causes, and in short, the size of the ecological footprint it leaves on the environment, is extremely important in terms of guiding the activities of human beings. Ecological footprint awareness is of great importance for each

individual to realize the opportunities offered by the environment in which he lives, to know how the traces left on nature will be reflected to him and to future generations and to take responsibility for the actions to be taken.

The aim of this study is to examine the ecological footprint awareness of prospective science and technology teacher candidates with artificial neural networks as well as traditional education methods.

5. Recommendations

It can be said that science and technology teacher candidates' ecological footprint awareness levels are weak, when the research findings and results are examined. In order to improve the results of the research, the following suggestions can be made:

- The design and implementation of the ANNs system can be designed to meet the need for automatic questioning as an expert questionnaire for future technology-based measurement and evaluation activities.
- Teacher candidates should be taught that there is a limit to the biological capacity of the world and its ability to renew itself, that the footprint left by the world and our country on nature gradually increases, and that this will lead to problems that cannot be compensated.
- All public opinion should be made aware of this issue through visual and written media, and what is expected of living things should be shown to people with various animations or films.
- Teacher candidates should be informed as an example for countries with small ecological footprints.
- Teacher candidates should prepare projects to minimize their ecological footprints and thus encourage them to find solutions to environmental problems.
- The parents of the young generations, parents and teachers should be made aware of this issue and be set an example to their children with their behavior.
- This study should be carried out on large firms and industrial organizations producing and they should be made aware of this issue.

Since there is only one world to meet the needs of human beings, it is the duty of all humanity to reduce the ecological footprint. However, one of those who will undertake the task of raising this awareness is teachers.

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